

July 2, 1963

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3,095,642

METAL AND FIBER COMPOSITE MATERIALS AND METHODS OF PRODUCING

Filed Nov. 26, 1957

2 Sheets-Sheet 1

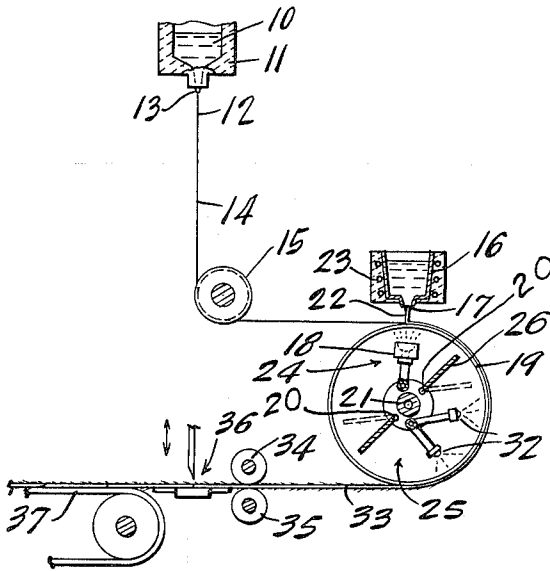


FIG-1-

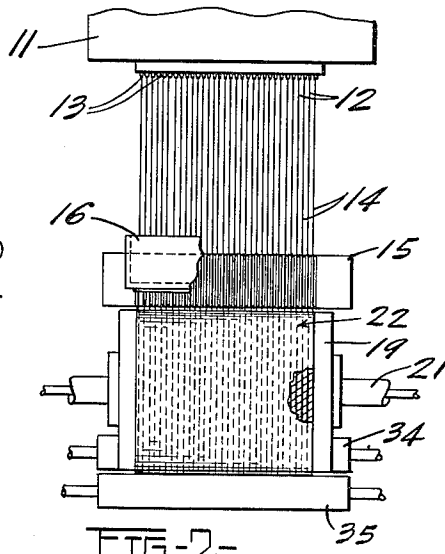


FIG-2-

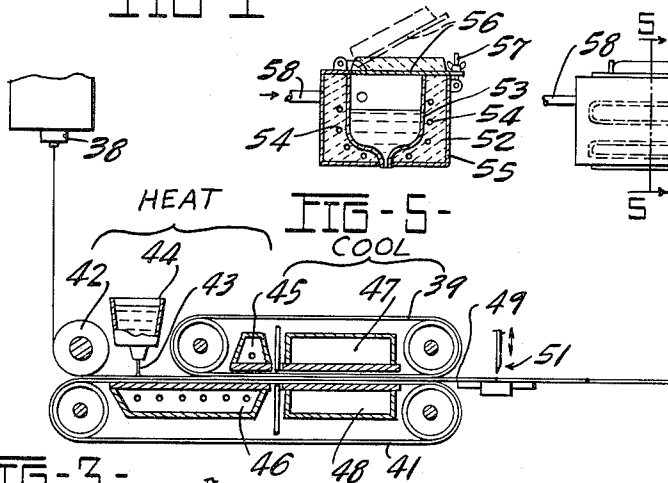


FIG-3-

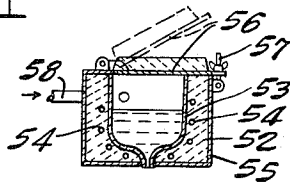


FIG-4-

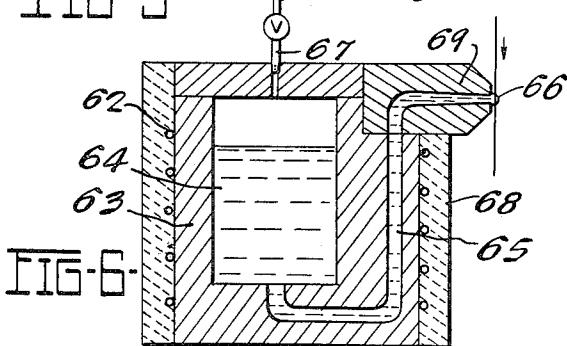


FIG-5-

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2 Sheets-Sheet 2

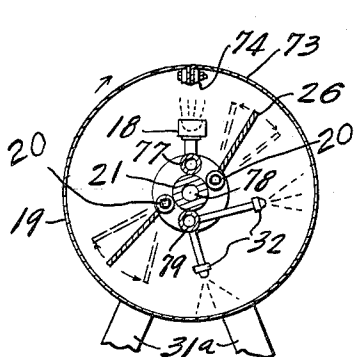


FIG-8-

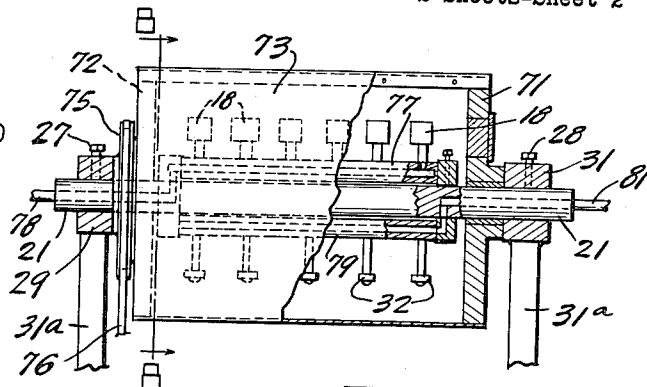


FIG-7-

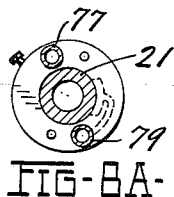


FIG-8A-

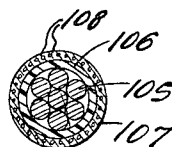


FIG-12-

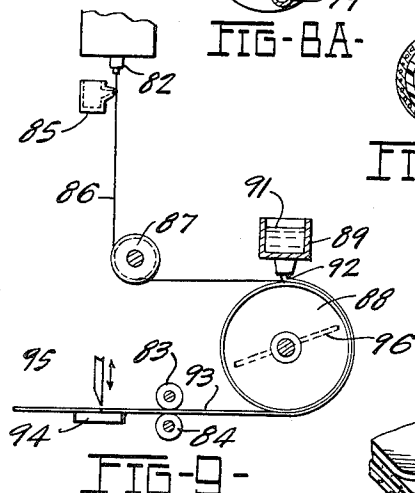


FIG-9-

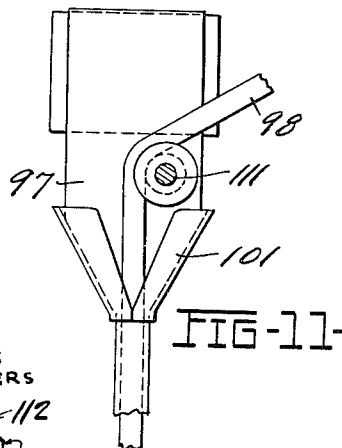


FIG-11-

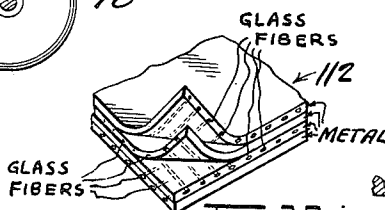


FIG-13-

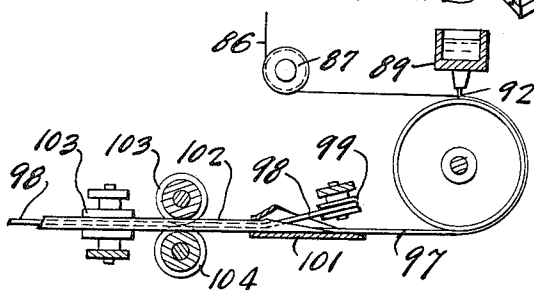


FIG-10-

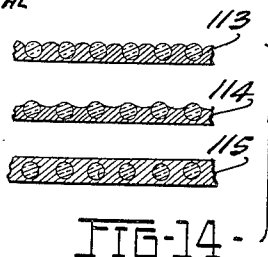


FIG-14-

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METAL AND FIBER COMPOSITE MATERIALS AND METHODS OF PRODUCING

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5 Claims. (Cl. 29-419)

This invention relates to metal and glass composites and particularly to an improved process for combining molten materials and fibrous materials in a continuous manner to produce improved products.

In the past many attempts have been made to combine plastics, resins, asphalts, hot melts, waxes, molten metal and the like with fibers to produce bonded fibrous products and fiber reinforced products. Much work has been done in developing coating processes wherein a molten metal is applied to fibrous glass as it is being formed to provide a uniform coating of metal upon individual fibers which are then gathered into a strand or bundle of fibers. Such a process is disclosed in U.S. Patent No. 2,772,518, issued to Whitehurst and Otto. Prior to the present invention no known process for producing sheets of metal reinforced with fibers or sheets of metal bonded fibers has been available.

Therefore, it is an object of this invention to provide methods for combining fibrous material and molten material to produce composite forms of these materials.

It is a further object to produce glass-reinforced metal sheets suitable for use as sheets or as laminae in strong reinforced products.

It is also an object to produce metal-bonded fibrous products in sheet or similar forms.

According to the broad concepts of the invention, a molten material is introduced onto fibers which are arranged and supported in a side-by-side relationship and the molten material is solidified to provide a sheet-like product. The invention will be described with regard to a combination of specific materials but it is not to be limited thereto since the specific disclosure is made only for purposes of illustrating the invention.

The invention will be best understood by reference to the drawings wherein:

FIGURE 1 is an elevational view, parts being in section, of apparatus for carrying out the invention;

FIGURE 2 is another view of the apparatus shown in FIGURE 1;

FIGURE 3 is a side elevational view, parts being in section, of another form of apparatus for carrying out the invention;

FIGURE 4 is a side elevational view of the metal pot; FIGURE 5 is a cross-sectional view on line 5-5 of FIGURE 4;

FIGURE 6 is a sectional view of a pressurized metal pot;

FIGURE 7 is a view of a drum which is partly broken away to show burners and air nozzles;

FIGURE 8 is a sectional view on line 8-8 of FIGURE 7;

FIGURE 8A is a detailed view of the manifolds and shaft assembly;

FIGURE 9 is an elevational view of another form of apparatus for carrying out the invention;

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FIGURE 10 is a view of forming apparatus including a folding shoe and wire spool for forming metal-encased wire;

FIGURE 11 is another view of a folding shoe apparatus for forming a sheet about a wire;

FIGURE 12 is an enlarged sectional view of the product made with the apparatus of FIGURE 10;

FIGURE 13 is a sectional view of a laminate formed of multiple layers of glass and metal sheets; and

FIGURE 14 depicts several forms of metal and fiber sheets produced by the methods of this invention.

In FIGURE 1 the apparatus comprises a feeder 11 which contains molten glass 10 that flows through the nipples 13, 13 in the form of streams 12, 12 of molten glass which are then attenuated into fibers 14, 14. The fibers 14, 14 pass around grooved roll 15 which maintains the fibers in a spaced-apart relationship as they travel toward and around drum 19. End plates 71, 72 of drum 19 are journaled upon shaft 21 so that drum 19 is rotatable. Drum 19 is turned by a motor, not shown, through drive belt 76 and sheave 75, see FIGURE 7 also. Above drum 19 is positioned a metal pot 16 from which molten metal 22 flows, the molten metal passing through slot 17 in the bottom of the metal pot. The metal pot is heated by a suitable electrical resistance heating means 23. Calrod heating units are used if desirable. Drum 19 which has an outer periphery of a heat resistant metal such as stainless steel is heated from within by radiant burners 18, 18. The inner portion of the drum is divided into a heated section 24 and a cooled section 25 by pivotable baffles 26. Baffle 26 is secured to the shaft 21, the shaft 21 being clamped into the proper position by means of set screws 27, 28, see FIGURE 7.

Baffles 26 are positioned by loosening set screws 27, 28 and turning shaft 21 in supporting members 29, 31. When the baffle has assumed the desired position, set screws 27, 28 are again tightened to hold the shaft 21 in position in relation to supporting members 29 and 31. Baffles 26 are also pivotable upon their supporting pins 20.

Cooled section 25 contains air nozzles 32, 32 through which air is passed to reduce the temperature at the surface of the drum. Heated section 24 contains burners 18, 18 which burn gas to provide heat at the surface of the drum.

When the apparatus of FIGURE 1 is operated, the streams of glass that bead downwardly from the feeder 11 are pulled by hand and wrapped around grooved roll 15 and placed upon drum 19. The drum is then rotated with the fibers on its surface and molten metal from pot 16 is flowed onto the fibers and surface of the drum. Molten metal 22 flows around the fibers and substantially fills the spaces between fibers as the fibers pass around the drum. When the fiber with the metal thereon reaches the cooled section, the molten metal solidifies and a sheet of metal and fibers 33 passes from the surface of the drum and is introduced between pull rolls 34, 35. Pull rolls 34, 35 advance the streams of molten glass 12 and attenuate the streams into fibers 14. They advance the sheet of material 33 being formed upon the drum and also work the sheet to smooth out some of the imperfections. If desired, the rolls are embossed to provide a desired surface configuration to the sheet. The

sheet of material then advances into the cutter assembly 36 which cuts the sheet into the desired length. The sheets cut to length are then either stacked or advanced upon conveyor 37 for subsequent packing or storage.

In FIGURE 3 another form of apparatus for carrying out the invention is shown. The glass feeder 38 issues streams of molten glass which are then attenuated by the coaction of conveyor belts 39, 41. The fibers being advanced by the conveyor belts pass around idler roll 42 and molten metal 43 from the metal pot 44 is introduced upon the fibers. As the metal and fibers advance, they pass between the conveyor belts and are heated electrically in zone 1 by heating boxes 45, 46 and then the resultant sheet advances into zone 2 where heat is removed by boxes 47, 48 cooled with air or water. The metal solidifies to form a metal and fiber sheet which then advances into the cutter blade assembly 51 where the sheet is cut into the desired lengths. The conveyor belts here act as the means for applying the attenuating force to the streams of glass to form fibers and they also act as forming means for producing the desired configuration upon the surface of the sheet being produced. Furthermore, the conveyor belts conduct the heat to the metal and glass being combined to form a sheet. Conveyor belt 41 not only acts as the drum of FIGURE 1 but also acts as the lower pull roll of FIGURE 1.

In FIGURES 4 and 5 details of the metal pot are shown. The pot comprises a thermal insulating shell 52 and a graphite inner liner 53. Spaced about the outer side of the graphite liner 53 are electrical heating elements 54, 54. The whole assembly is enclosed in a metal shell 55 which is provided with a hinged lid 56 that locks in the closed position when lock assembly 57 is closed. An inlet 58 for the introduction of a gas such as nitrogen or another suitable inert material and electrical leads 59, 61 which provide power for the heating elements 54, 54 are located at opposite ends of the metal pot as shown in FIGURE 4.

Another form of metal pot is shown in FIGURE 6 wherein a graphite-lined pot which can be pressurized is illustrated. The metal pot is provided with electrical heating means 62. The graphite lining 63 holds molten metal 64 which flows through passage 65 to form an elongated bead of metal 66 through which the fibers pass to be metal coated. A gas under pressure is introduced through inlet 67 to put pressure upon the molten metal 64 within the metal pot 68 to force the molten metal through the passage and out the slotted nozzle 69. Such an apparatus as the shown can be positioned immediately below the feeder in the apparatus shown in FIGURE 1 or 3 or, if desirable, the apparatus shown in FIGURE 6 can be turned on its side or modified so that the metal issues from the bottom of the metal pot and then the metal pot can be positioned over the drum or conveyor belt to introduce metal in molten form upon the fibers. In addition to obtaining a control over the flow of metal from the pot, the pressure device can translate force to the molten metal, if desired, to assure impregnation of the fiber collection with metal.

In FIGURES 7 and 8 details of the drum, upon which the composite products are formed, are shown. The drum comprises two end plates 71, 72 and a cylinder of sheet metal 73, the sheet metal 73 being wrapped around the end plates with the meeting edges clamped with bolts 74. End plates 71, 72 are journaled upon shaft 21. End plate 72 is provided with a sheave 75 which is turned by drive belt 76 and a motor, not shown. Radiant burners 18, 18 are connected to manifold 77 through which a fuel such as a gas-air mixture is introduced, the manifold being connected to inlet 78. Air nozzles 32, 32 are interconnected by manifold 79 which has an inlet 81.

Metal is advantageously applied in two stages such as in the process illustrated in FIGURE 9. Streams of molten glass flow from feeder 82 whereupon they are attenuated

into fibers by the action of pulling rolls 83, 84. Metal applicator 85 is positioned adjacent to feeder 82 to apply metal to the newly formed fibers. An elongated globule of metal is suspended from the lip of the metal applicator and the fibers as they are being produced pass through the globule of metal to pickup a metal coating. Metal coated fibers 86 pass around idler roll 87 and onto drum 88. A metal is applied to the already metal coated fibers from metal pot 89. Molten metal 92 from metal pot 89 flows onto the fibers positioned in side-by-side relationship upon drum 88. As the fibers 86 and metal 92 pass around the drum, the molten metal 92 solidifies to form a sheet of metal and fiber 93. As the sheet of metal and fiber passes between pull rolls 83 and 84 and over chopping block 94, cutting blade 95 is actuated to cut the sheet into the desired lengths. Drum 88 is provided with a baffle 96 which separates the hot and cold zones within the drum. This baffle is positionable so that the hot and cold areas of the drum can be varied as may be desired.

The sheets produced by the apparatus shown may be used to form laminates or the sheet can be used to wrap wire with apparatus such as that shown in FIGURE 10. The glass and metal composite 97 is wrapped upon a wire 98 which is unreel from spool 99. Folding shoes 101 causes the sheet being produced to be wrapped about the wire to form a sheath. Coated wire 102 then passes between a series of rollers 103, 104 to work the metal-glass coating into the smooth sheath desired. A cross section of a product formed with the apparatus of FIGURE 10 is shown in FIGURE 12 wherein a multiple strand wire 105 is coated with insulation 106 and a metal-glass sheath 107. Fibers 108 are shown embedded in the metal-glass sheath 107. A larger view of folding shoe 101 used in wrapping the metal and glass composite about a wire is shown in FIGURE 11. The glass and metal composite sheet 97 is shown passing into folding shoe 101 along with wire 98 which passes around idler 111. The sheet is wrapped about the wire to form an enclosing sheath. After this operation the forming rolls are used to work the metal to insure a complete enclosure of the metal on glass composite about the wire.

A laminate 112 is illustrated in FIGURE 13 wherein sheets of metal with glass fibers 115 therein are laid up with the fibers in adjoining sheets running at angles of 90° with respect to one another so that strength is imparted to the final laminate in more than one direction. In manufacturing laminates it is oftentimes advantageous to apply more than one metal to the glass fibers. This is true since some metals bond strongly to glass surfaces while others may not bond as strongly. If it is desirable to form the laminate of a metal which does not readily adhere to glass surfaces, then it is expedient to apply a metal, as with an applicator 85 such as that shown in FIGURE 9, to the fibers as they are produced and then combine the metal coated fibers with another metal applied with an applicator 89. For instance, when it is desirable to coat glass fibers with lead which does not readily wet glass, an alloy of lead with a small percentage of cadmium and zinc is applied first and then the lead alloy coated fibers are combined with lead to form a sheet.

In FIGURE 14 several forms of composite products are shown. The different effects result depending upon the wetting characteristics of the metal and the glass fibers. In addition to variance in wetting characteristics, the surface tension of the metal being applied is a factor which relates to the configuration achieved. The configuration 113 illustrates a sheet comprising fibers not readily wetted by the metal being combined therewith. If the metal has a high surface tension, it will tend to draw up into convex portions between fibers as shown. If this sheet is combined with additional metal and directed through rolls, a smooth surfaced sheet 115 will be provided even though there may not be complete wetting

out of the fibers by the metal during formation of the sheet. Sheet 114 shows a metal having low surface tension or one that shrinks considerably upon cooling.

Complete wetting out of the fibers by the metal is generally desirable to achieve ultimate strengths. In certain uses it is desirable to allow the fibers to slip with respect to the surrounding metal in the composite sheet.

In producing the materials described any of various glass compositions can be used as illustrated by those defined in the Schoenlaub Patent 2,334,961, Tiede Patent 2,571,074, Whitehurst and Otto Patent 2,772,987, and Tiede Patent 2,733,158. It is generally desirable to match the metal being applied to the glass with the particular glass being used; however, this is not critical in that it makes no particular difference whether the glass is wetted by the metal being combined therewith or not. Since the temperature of the molten metal applied at the drum can be controlled and the cooling rate can be controlled, a composite product can always be achieved. This is regardless of whether or not the metal actually adheres to the glass surface.

The metals to be applied may vary widely likewise. Generally the melting point of the metals or alloys being applied will vary from about 125° F., to about 2000° F. Metals such as aluminum, lead, zinc, cadmium, bismuth, tin, copper, silver, cerium barium, magnesium, lithium, tellurium and alloys of these materials including aluminum alloys, lead alloys, zinc and cadmium alloys, copper alloys, lead and bismuth alloys, bronzes and brasses may be used in addition to others. Alloys containing more than two metals may likewise be used. The metal pot maintains a supply of molten metal and furthermore meters that molten metal onto the fibers to achieve the desired proportion of metal to fiber. It is not always necessary to pressurize the metal within the metal pot in order to achieve the metal to glass ratio desired. A single fiber may be combined with metal or a plurality of fibers may be so combined. 204 or 408 fibers are conveniently combined with metal with the apparatus illustrating the invention. Yarns, strands, or textile fibers may be treated with metal using the apparatus shown; however, it is generally preferred to treat individual fibers to achieve intimate mixtures of metal and fiber.

The heating zone within the drum or conveyor adds heat to the fiber and metal mass on the drum which makes it possible for the metal to flow as it is being combined with the fibers. The added heat may actually elevate the temperature at the combining point or the added heat may simply maintain the temperature at the surface of the drum where the metal is combined with fibers. It is desirable to have the metal pot or applicator positioned closely to the drum or conveyor. The drive rolls in addition to advancing the material being formed and attenuating the fibers also smoothes out wavy portions in the sheets produced and works out any minor imperfections. The diameter of the fibers added to the metal may vary widely; however, they will generally be not greater than about three thousandths of an inch in diameter and may be very fine fibers of small diameter.

The products so produced may be used for many things including such items as thin corrosion resistant material for sheathing, telephone cable, for sheets that may be laminated, and for stock which may be extruded into desired shapes.

If desirable, continuous fibers or staple fibers can be sprinkled down upon the parallel fibers being advanced toward the drum and then molten material applied as before to make a composite product. A mat of chopped continuous strands or fibers or a swirl mat of continuous strands or a mat of staple fibers can be introduced onto the parallel fibers prior to combination of molten metal with the fibers. The molten metal is advantageously sprayed onto the mat and parallel fibers in order to get good intermixing of the metal and glass. A mat surface can be provided for both sides of the structure by intro-

ducing a mat on each of the parallel fibers advancing onto the drum.

The temperatures used in applying materials will vary depending upon the materials; however, by way of illustration the metal operating temperature for lead is about 650° F. while the temperature inside the drum will be maintained at a temperature of about 850° F. When applying aluminum, the metal operating temperature will be maintained at about 1350° F. and the temperature within the hot zone of the drum will be from 1400° F. to 1800° F. The operating temperature of the metal within the metal pot will generally be about 50° F. to 300° F. higher than the temperature of the metal as it reaches the drum.

The fibers may be introduced onto a stationary supporting surface and slid thereover during formation of a sheet if desirable. Also the speed of the supporting surface may be greater or less than that of the fibers resulting in the fibers sliding over the surface.

Various modifications may be made within the spirit and scope of the appended claims.

I claim:

1. Method of producing a flat sheet of metal and fiber comprising advancing fibers as they are formed from a supply of molten material, arranging the fibers in a parallel pattern as they are advanced, directing the fibers onto an advancing supporting surface, introducing molten metal onto the prearranged fibers to flow the metal between and around the fibers on the advancing surface, solidifying the metal to set the fibers in the pattern formed and thereby create a sheet of metal and fiber, and removing the flat sheet of metal and fiber from said advancing surface.

2. Process for producing reinforced sheet comprising advancing a plurality of fibers in a side-by-side relationship, introducing the advancing fibers onto a supporting surface, introducing a melt onto said supporting surface, adding heat to the supporting surface to assure flow of the melt about the advancing fibers, cooling said supporting surface and melt to solidify the melt and lock the fibers in their side-by-side relationship, and removing the reinforced sheet from said supporting surface.

3. Process comprising supporting glass fibers upon an advancing surface, flowing a molten metal upon said fibers, heating the advancing surface to promote the flow of the molten metal about the fibers, cooling the advancing surface to solidify the metal, and removing a glass fiber and metal sheet from said advancing surface.

4. Method of producing a sheet of metal and fiber comprising advancing a plurality of side-by-side, individual fibers as they are being formed, suspending a globule of molten metal from the lip of a metal applicator and passing the advancing fibers through the suspended globule thereby applying a coating of metal to the advancing fibers, passing the advancing, metal-coated fibers at least partially around a grooved roll to maintain the advancing fibers in a spaced-apart relationship, directing the metal-coated fibers onto an arcuate supporting surface and introducing molten metal flowing from a metal pot onto the fibers and supporting surface to flow additional metal between and around the spaced-apart fibers, cooling the molten metal to form a sheet of metal and spaced-apart fibers, removing the sheet of metal and fibers from the supporting surface and passing the sheet between a pair of pull rolls which advance the sheet and the fibers being formed.

5. Process of claim 4 wherein the pull rolls emboss the sheet as the sheet passes therebetween.

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